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THE DESIGN AND OBJECTIVES OF LABORATORY PROBLEM IV

I. K. Cohen

PREPARED FOR:

UNITED STATES AIR FORCE PROJECT RAND

The RAND Corporation
SANTA MONICA • CALIFORNIA

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PREFACE

LP-IV, the fourth experiment of the Logistics Systems Laboratory, is now in preparation. Its primary focus is on maintenance management at air base level.

In the course of a logistics problem (LP), it is necessary to contact many Air Force organizations for data and other information, and to obtain participants in the experiments. Therefore, it is customary to visit the relevant headquarters and brief them on the particular experiment.

This RAND Memorandum contains the text of such a briefing, which is intended to provide Air Force staff officers with an over-view of LP-IV: its objectives, policy areas to be investigated, the man-machine simulation model, technical approach, current status, and future plans. It was presented during September 1962 at Headquarters SAC and to the staffs of the Assistant for Logistics Planning and the Director of Maintenance Engineering of DCS/Systems and Logistics at Headquarters USAF.

Further background on the Logistics Systems Laboratory is given in M. A. Geisler, W. W. Haythorn, and W. A. Steger, Simulation and the Logistics Laboratory, The RAND Corporation, RM-3281-PR, September 1962, which describes the history of the Laboratory and the three previously held experiments.

SUMMARY

The fourth Logistics Laboratory Problem (LP-IV) has been designed primarily to study improvements in base-level maintenance management and information systems. LP-IV's secondary objectives are to develop a systems training capability for base maintenance management, and to advance state-of-the-art research in management. Several factors determined the study's subject matter: a continuing squeeze on maintenance support resources; a need to weigh proposed refinements in AFM 66-1, as well as the value of advanced data processing systems; and a broad background of available RAND research data and techniques.

The LP-IV study will intermix a number of research techniques, including man-machine simulation, all-computer simulation, and statistical analyses.

In evaluating the policies under test, LP-IV will employ several broad classes of interrelated criteria: direct increase in operational capability, more complete and accurate picture of base maintenance activities within existing resource constraints, more effective use of resources, and improved ability for future planning.

To establish a manageable number of policies susceptible of intensive study within LP-IV, both Air Force and RAND personnel are currently screening a long list of potential candidates. On the maintenance policy side, such areas as flight-line dispatch rules, priority systems for shop processing, and shift manning are being explored. On the data processing and data display side, the investigations range from refinements of codes and forms now used in AFM 66-1

to the design and test of a fully automated and centralized maintenance data processor.

In addition to examining each policy area, this Memorandum also describes briefly the man-machine simulation model planned for LP-IV. The model will be manned by Air Force personnel experienced in such functions as DCM, job control, production control, maintenance plans and schedules, reports and analyses, and shop supervision.

The over-all LP-IV design visualizes a benchmark or yardstick case against which proposed policy innovations can be measured. The benchmark case -- a B-52/KC-135 maintenance management activity -- is built with real-world data and policies abstracted from AFM 66-1. Changes in benchmark policies or procedures will be assessed during a series of "B+1" and "B+5" runs. The former imply innovations for which possible field implementation could be accomplished in a year or less; the latter innovations would require several years for field implementation.

At present, a mockup of the benchmark case is underway in the Laboratory. A "record" run for the benchmark case is targeted for January, 1963. It is proposed that Hq. USAF and several major air commands meet with RAND in January, 1963 for further discussions regarding policies to be investigated in the "B+1" and "B+5" runs during calendar year 1963.

CONTENTS

I. INTRODUCTION

Laboratory Problem IV concerns base maintenance management and base information systems.

Through the use of field and statistical studies, man-machine simulations, all-computer simulations, and through the joint efforts of several RAND groups, LP-IV will pull together past research findings, and others still under development in an intensive effort to meet three major objectives.

Our first is to develop and evaluate an improved base maintenance management system. In this development we will pay particular attention to the multi-weapon/multi-command type of Air Base that is emerging for major segments of the Air Force. We will stress the development of a unified structure of goals and sub-goals for base maintenance management. We believe that there is much value in demonstrating to the Air Force the specific benefits that a unified goal structure can give to base-level maintenance. Within the context of such an explicit structure, we would formulate a set of preferred maintenance policies and define an information and data system that both simplifies and improves the numerous base-level information collection, processing and analysis tasks. In addition, higher command echelons and AFLC depend upon information produced at base-level for much of their work; to this point, LP-IV will improve the level of aggregation necessary to meet such off-base requirements. Finally, we anticipate that such a data and information system should facilitate the use and development of a number of maintenance management control techniques.

Our second objective is to develop a training and evaluation capability for base maintenance management. In our base visits, we have frequently heard a need expressed for more training in maintenance management functions. In our previous LPs, participating officers and airmen -- during their stay at RAND and after their return home -- have frequently said that their LP experience was of considerable help in the performance of their on-station jobs. We are also aware of the interest in an education and evaluation device by the AF Log School at Wright-Patterson. We believe that the laboratory facility planned for LP-IV is, in fact, a prototype training facility. From it we plan to derive a set of specifications and models for use by the Air Force.

The third and final objective relates to our recognition that our know-how for conducting R & D on large management information systems is subject to considerable improvement. In LP-IV, we plan to attend to the several important methodological issues which will advance the state-of-the-art in this area.

This presentation gives special emphasis to the first of the three major objectives.

II. IMPLICATIONS FOR THE AIR FORCE

The decision to intensify our study of base maintenance management was made after a careful review of a number of critical factors.

With the introduction of AFM 66-1 several years ago, significant progress has been made in the base maintenance management area. But software systems, like hardware systcms, require product and systems improvements if they are to continue to serve the manager effectively. With Air Force experience in the use of 66-1, with the potential gains indicated by completed and in-process research at RAND, and with the heightened interest by the other services in 66-1, it is timely for an augmented effort to pull together and evaluate ways to improve base maintenance managements. We plan to "home-in" more precisely on the elements of data required by maintenance managers, and to develop techniques for reducing data into timely reports for effective maintenance direction. An intensive study undertaken in data processing techniques that will be commonplace in the middle and late sixties as well as in the data processing framework of today will help assure the Air Force that base maintenance management systems keep pace with changing technologies as well as with current and anticipated requirements.

Another of the factors that compelled this topic choice for LP-IV concerns the matter of such maintenance resources as personnel, support equipment, facilities and spares. The pressures for reducing these resources is not likely to subside. As a matter of fact, we see mounting pressures for:

1. meeting higher operational alert requirements,
2. reducing the rising cost of base maintenance,
3. meeting the challenge of the reported shortages in base manpower,
4. managing mixed weapon inventories, and
5. meeting quick or selected response requirements.

And though numerous illustrations exist within the Air Force showing how changes in management policy have had positive effects on performance, a considerable amount of research experience continues to be available for improving base maintenance management further. LP-IV's backdrop of broad experience started in 1954 with RAND's involvement in Project Lock-On with ADC and, over the years, includes such highlights as the work on Management Information for the missile force, the detailed analysis of the SAC ground and airborne alert problem through computer simulations of base maintenance operations interactions, the work on analyzing the ADC Full-House test data, and the LP-II studies of such problems as resource allocation and maintenance scheduling for the ICBM. RAND is currently working at Oxnard AFB to determine whether, with minor additions to the current 66-1 system, significant weapon-centered data can be provided to maintenance managers.

References to these studies plus a more complete listing of the background data available to LP-IV is included in the bibliography at the end of this Memorandum. This is a considerable amount of on-the-shelf research information. A number of these studies have been found useful by the Air Force in developing its maintenance

management system. However, others have never been put together in a consistent and extensive test or analysis as planned in LP-IV. By employing these available proposals in a realistic Laboratory setting, both RAND and the Air Force will be able to make assessments of their utility and suitability for possible field implementation.

III. CRITERIA

In LP-IV's test of alternative maintenance policies and data systems, prime consideration will be given to relating proposed innovations to the following four broad classes of interrelated criteria:

1. direct increase in operational capability,
2. more complete and accurate picture of base maintenance activities,
3. more effective use of resources, and
4. improved ability for future planning.

In tying proposed improvements to these criteria, we are attempting to make explicit and coherent a goal structure we believe properly befits base-level maintenance activity. Too often, we find certain aspects of base maintenance criticized only because the critics have assumed goals or sub-goals different from those assumed at the base level itself. For example, a preoccupation with leveling workload and increasing utilization of maintenance specialists may easily degrade operational effectiveness. Nevertheless, we have seen a number of manpower type studies that explicitly urged smoothing of workload and increasing manpower utilization upon base-level managers with no apparent recognition that operational effectiveness might be compromised by doing so.

Another illustration: we often see flurries of concern because large numbers of man-hours are used against a particular type of malfunction. A closer look at some of these situations reveals that

this concern might best be expended against malfunctions requiring less dramatic man-hour expenditures, but which are more likely to affect mission capability. Another way of saying some of this is that it often appears as if we are not sufficiently mission and weapon-oriented in our maintenance management.

Starting from our four broad categories of criteria, we may next review briefly their meaning for our experimental plan.

First, in order to obtain increases in operational capability, we plan to examine a range of maintenance policies that are likely to provide such payoffs as decreasing turnaround times, reducing the number of late takeoffs, improving EWO generation schedules and increasing the number of weapons in alert status.

Second, representing a base through its data system must satisfy not only its own management, but also must meet the requirements of higher command echelons, AFLC, and Hq. USAF. Where possible we shall try to measure the effect of more or less information on operational capability and flexibility; where effects of information cannot be measured, we will strive to provide the best information possible within existing cost restraints. We plan to illustrate ways of obtaining better weapon status and operational readiness capability measurements, and improved maintenance action statistics through inclusion in the data system of such critical items as team size, team composition, elapsed time for repair actions and weapon down-time. And we shall also give serious attention to the matter of identifying improved data analysis and data presentation techniques that depict base maintenance activities and performance so all users will obtain

more easily and quickly the data required for faster and more responsive decision-making.

Third, under improved resource usage, we shall concentrate on such matters as reducing maintenance man-time spent in data collection, reducing manpower required for routine planning and controlling, and providing mechanisms for determining shift and scheduling policies that rationally befit increased operational capability.

The last criterion category is obviously related to the other three. Improved data emanating from base level should permit development of better manning and equipping factors for both base- and higher-level planning. Similarly, with more precise and accurate elapsed time data, EWO planning is likely to improve. A sound data system should also give firmer assessment of policies placed in field test. And finally, such AFLC concerns as inspection intervals and replacement policies, should become more effective as the data system draws a more complete and accurate picture of base-level activity.

IV. POLICY AREAS

We are currently reviewing a large number of ideas on information system design and preferred policies for base maintenance organizations. Some of these ideas are available from the RAND research conducted over the past many years; some have received relatively little research attention. One of our key problems is isolating a manageable number worthy of intensive evaluation. We are using several approaches to narrow down the field. On the one hand we have had many interactions with seasoned personnel at base, air division, and numbered Air Force levels in an effort to evaluate the importance of some of the available ideas. (We plan to extend these discussions to major air command levels.) To complement this approach we shall, within the next month or two, employ an all-computer model to screen other likely alternatives. When we have finally sifted through the available candidates, a most promising and manageable number will be evaluated and demonstrated in the context of a man-machine simulation within our Logistics Systems Laboratory. Although the final list of policies has not yet been drawn up, we can at the moment sketch in broad terms some of our current thinking. For convenience, we will discuss initially those policies relevant for the current hardware data processing framework. Following that, we will cover policies that require an advanced data processing hardware framework.

V. POLICY INNOVATIONS WITHIN CURRENT HARDWARE FRAMEWORK

Let me reassert that our list of policies at this time is a menu; from it we shall select the most promising ideas for LP-IV analysis, final evaluation and demonstration. Since we have not yet completed this sifting process, we hope that you will add to our list and also assist us in selecting those candidates worthy of detailed attention.

At present, our list is so long that it will not be possible to cover each of the policy areas in depth at this time. Thus, the areas will be covered in general terms; one or two will be given in some reasonable detail.

FLIGHT-LINE MAINTENANCE DISPATCH

Since we are anxious to have an impact on operational capability it is easy to understand our interest in dispatch rules. In this area, we are likely to examine a large list of alternatives. For example, some SAC bases batch discrepancies that arise one day, and schedule repair for early the next morning. This scheme contrasts with the Highblower concept at other bases, wherein a large recovery team meets the aircraft on landing, works for eight hours and if all the discrepancies have not been cleared, turns the remaining schedule function over to job control. We would like to determine whether important differences in cost-effectiveness arise as a result of variation in time lag between discovery of a discrepancy and start of the repair action. Perhaps, instead of meeting the airplane on landing with a large team, as is the case in Highblower, we can do

better by using a small team to obtain the discrepancy information and scheduling repair within a few hours after landing. Several other policies, not by definition dispatching policies, but ones which will undoubtedly greatly affect the results of any dispatching rule will also be investigated. For example, we will eliminate tail number scheduling while adhering to a rigid flying schedule.

SHOP MANAGEMENT

One of the key shop management areas of investigation will be the priority system used to select the next job for processing. Some of the alternative rules we will study are: shortest completion time, a priority equal to some function of the present serviceable balance, and a priority equal to some function of the stockout probability on the particular item. Superimposed on these priority rules will be several other policies including a decision rule for pre-emption of a particular job in favor of another one. We will also contrast the present centralized Production Control organization versus decentralizing to the individual shops the scheduling and priority determination. Before leaving the shop area, another investigation that we might mention is our intention to determine the rules, from a cost-effectiveness standpoint, to allocate specialists between shop and flight-line work.

SUPPLY SUPPORT

In the supply area, we are predominantly interested in the interactions between supply and maintenance. As a result, we will be inclined to study such matters as: the scheduling of pre-issue

stock repair, the availability of bench stock and other bits and pieces, the effects of supply shortage and maintenance reactions to shortage, the importance of response in supply status reporting to the maintenance operation, and the conditions under which cannibalization and repair action alternatives may be traded off with stockage policy parameters.

REPORTS AND ANALYSIS

An important segment of the Air Force is becoming quite sensitive to the need for developing a highly professionalized maintenance analysis capability. This segment holds that the experienced crew chief does not necessarily make for the excellent analyst. This group further believes that it is becoming more and more difficult to increase the effectiveness of maintenance organizations through good experience and intuitive judgment alone. The experience and judgment need to be supplemented by a skilled analytical staff.

We, at RAND, share this concern for professionalizing Air Force maintenance analysis capability. Thus, in tooling up for LP-IV, we have been paying a considerable amount of attention to the Reports and Analysis area. This attention has ranged across a broad spectrum of problems.

Perhaps our most important concern is identifying as many of those important problems as possible which maintenance managers are likely to face, together with the data required to shed light on such problems. Given that the required data are identified, understanding machine techniques appropriate to its processing and presentation in a timely and comprehensible fashion is also important. Finding new

and important means of isolating problems closely related to the weapon underlies this process. One of RAND's studies in this connection has been a field test in cooperation with ADC at Oxnard Air Force Base where a first step was clear; namely, identifying those questions which base maintenance management needed to answer, followed by the necessary augmentation of AFM 66-1 data. This test is currently in progress, but let me illustrate the direction of this work.

A daily listing of aircraft status is provided to base maintenance management. From this listing, it is possible to follow rapidly and easily action taken on a particular aircraft hour-by-hour or note failure to take action, thus isolating problems in the management of this aircraft as well as inconsistencies in the data reported becomes fairly straightforward. Given such data, analysts will be in a position to assess the status of maintenance activities and suggest ways for improving them. Using the same data collected we are able to print-out by machine, for each work center, work performed and resources used hour-by-hour. In LP-IV we plan to extend this development to further improve presentation modes with EAM and computer equipment, as well as explore additional means for adequately summarizing such data for use by Wing Commanders, numbered Air Force echelons, and major air commands. The main point of these two illustrations is that we are developing easy means to answer key management questions by:

1. providing more weapon-oriented data,
2. providing correct data,

3. discovering unknown factors and relationships,
4. reducing comprehension time, and
5. improving the accuracy of the comprehension process.

Another possibility that we have been examining in the context of LP-IV is an exception reporting system to augment regular reports. Under such a system, control limits would be established for such items as overtime, NRTS, leave, training, man-hours and clock hours to fix, discrepancies per sortie, etc. A report would be generated when significant "out-of-bounds" or "out-of-tolerance" conditions exist.

We have also examined a large number of maintenance measures in order to determine their interrelationships and their relationship to operational goals and sub-goals. Though this work is in its early phases, findings to date suggest that managers will find it helpful to know what the explicit statistical relationships are among the many available measures. For example, we have good statistical estimates of the changes that occur in overtime, shop production actions, supply response times, and the like, as repair activity at the aircraft increases.

Before leaving the R&A area, we should mention that in our work with the 15th Air Force, it became apparent to us that R&A people at base level and numbered Air Force level might benefit from an improved understanding and application of statistical techniques. As a result, we have developed a first draft "do-it-yourself" paper covering statistics for personnel currently in R&A organizations. In the course of LP-IV, we plan to update this paper.

PLANS AND SCHEDULING

It appears likely that the introduction of a greater amount of formal structure to the plans and scheduling process will provide some important gains especially in the context of a multi-command multi-weapon air base. Not only will we develop a more explicit set of rules for schedule preparation, but we would hope to provide a simple mechanism to predict workload and status from the schedules. The scheduler could then revise schedules until the predictions looked favorable. And, as was mentioned earlier in another context, we will look closely at the gains that might be made when planning for a firm flying schedule but relaxing on fixed tail number scheduling.

SHIFT POLICIES

We have observed considerable variation in shift policies employed by different base maintenance shops. For this reason, our main interest is examining the benefits to be derived from a more explicit shift policy change mechanism. If it should turn out that such a mechanism has high value, we would prepare a "cookbook" on how to set up a good fixed-shift policy, and how to determine whether the allocations of specialists across shifts should change. We plan also to use this approach in establishing an explicit control policy regarding overtime.

DATA INPUT

On the data input side, we will be studying the benefits and costs of: using data specialists on base, using data sampling

techniques in place of obtaining complete data enumeration, form and code design improvements, error checking techniques, and simple hardware introductions like the porta punch. For more details about this particular area, you might wish to look through B-221 and RM-2681. These publications are in the bibliography at the end of this Memorandum.

MANAGEMENT CONTROL SYSTEM (MCS)

The current MCS has a powerful effect on the behavior of managers in the command. With our work planned to define more explicitly the goal structure of 66-1, and our anticipated improved understanding of the relationship among maintenance measures and operational performance, we hope to explore in depth the gains that would be made with the explicitly defined goal structure.

MAINTENANCE ACTION AND DECISION-ORIENTED ANALYSES

Many Air Force activities and organizational elements, off as well as on-base, can use information about demand for maintenance and how the demands were met. Maintenance action data is central to the 66-1 system, and yet many users are critical of it. Some criticism stems from the lack of definitive statements regarding the goals pertinent to each activity level and organizational unit which 66-1 is designed to serve. Accordingly, LP-IV will catalog the decisions each potential user must make, and the data and data characteristics required to support these decisions. Given such a catalog, we will evaluate the importance of data elements through their relationship with system performance. We will also measure

the effect on system performance caused by varying such parameters as accuracy, timeliness and information content.

VI. POLICY INNOVATIONS WITHIN ADVANCED HARDWARE FRAMEWORK

Field studies of base maintenance management organizations have helped greatly to identify areas where increased use of computers might have some payoff.

INPUT DEVICES

The input data for the AFM 66-1 system currently require maintenance mechanics, whenever they perform any maintenance work, to fill out a form that goes into the system where it is keypunched, listed, analyzed and so on. One thing we know about this manual input system is that it is subject to error, since people make mistakes. These errors, hard to eliminate, frequently enter analyses and affect the entire management effort. We will be examining a range of input devices including the use of the automatic generation of malfunction reports directly from automatic checkout equipment. In effect, a card that might be produced by the automatic checkout equipment would replace aspects of the mechanic's report. We believe that our investigation into alternative input devices could improve the accuracy in the reporting system.

FILES

It is common for several elements of a maintenance organization to maintain their own ad hoc or authorized files of information. One apparent reason for this manual file decentralization is that each organizational element wishes to have access to data it values at will. In the context of LP-IV, we will be studying the value of

mechanizing and centralizing these files. With mechanization, we should be able to accrue benefits that derive from centralization while at the same time permitting ease of access. Such mechanized files might not only contain information cardinal to the issues of weapon status, but also might contain configuration control data, TCTO, periodics, time change requirements, reparable control, maintenance handbook and tech data, as well as resource location and status. Centralized mechanized files should open new and important analysis areas, since the problem of correlating different kinds of information should be eased considerably. And, providing line managers with such access should make it possible to evaluate the gains that would accrue if these same files could be interrogated by higher level managers on-base as well as by managers who are located at higher echelons such as Air Divisions.

DATA DISPLAY

The present 66-1 accounting machine outputs require a large amount of manual labor to cull these outputs for relevant data and building graphs or histograms. Maintenance personnel are spending considerable energy in assembling the data for presentation to managers for their decision-making. We will be evaluating the payoff of extending computer usage to automatically printing out numerical, verbal, and spatial information in the form of graphs and the like for immediate presentation to the base manager. As indicated earlier, we have already obtained some interesting printouts of this kind which have whetted the interest of several maintenance managers with whom we are working in the Oxnard experiment.

PLANS AND SCHEDULING

A computer could assist in many specific jobs now done by maintenance personnel. For example, job shop scheduling, performed manually in the Air Force, has been done automatically in certain industrial applications. We plan to examine the usefulness of this to the Air Force. The Maintenance Plans and Scheduling Office spends considerable time under pressure putting together a monthly schedule for the organization; taking the operational and maintenance requirements for the period, the availability of aircraft, manpower and equipment; and developing a detailed schedule of what will be done during the next month. Because operational plans change frequently, it is common for these Plans and Scheduling procedures to be repeated several times a week. We plan to automate this process and provide to Plans and Schedules a number of alternative possibilities with workload estimates and probability statements of success for each alternative. This approach proposed for monthly schedule development is also to be tested for the weekly schedule and the daily plan.

MAINTENANCE DATA CONTROL CENTRAL

Now, instead of treating the automation of input, files, and such output functions as Plans and Scheduling separately, we might integrate these automated functions to the point of having the computer become a central communication facility for maintenance management. Under this concept much of the means for generating and maintaining files, and communicating, processing and proposing alternative courses of action would be allocated to the computer and its

peripheral equipment. Management decisions would be allocated to the man. Such a system might be characterized by phrases such as "men working on line with the computer" or "men having direct access to the computer." We see this type of operation coming about in two phases. Figure 1 shows an outline of the first or communications phase. In it, the computer handles basic maintenance data and record keeping. Input/output devices are located in the shops and in what is now job control. All requests for action and notices of action taken flow through the processor. It can, therefore, perform such important tasks as checking the accuracy of data and the appropriate sequence of events. If, for example, neither the occurrence of a delay or a notice of job completion is received at a given point past the scheduled job ending, the processor prints out a "schedule departure notice" for the manager and a "request for schedule check" for the shop manager.

The amount of "data processing" done by the maintenance man is reduced. Forms of the 210-211 type are provided to him by the system in machine-readable form. He has a machine-readable badge to identify himself. The system provides the identity of his work center and the clock time of each reported event. Since all "action data" flows through the processor, no special and cumbersome "historical data system" is required. All reports are prepared by the processor from its data reservoir -- the event history file.

The first phase is relatively straightforward to develop and implement. The processor is not being asked to perform complex tasks, but merely to keep records and transmit data. In the early

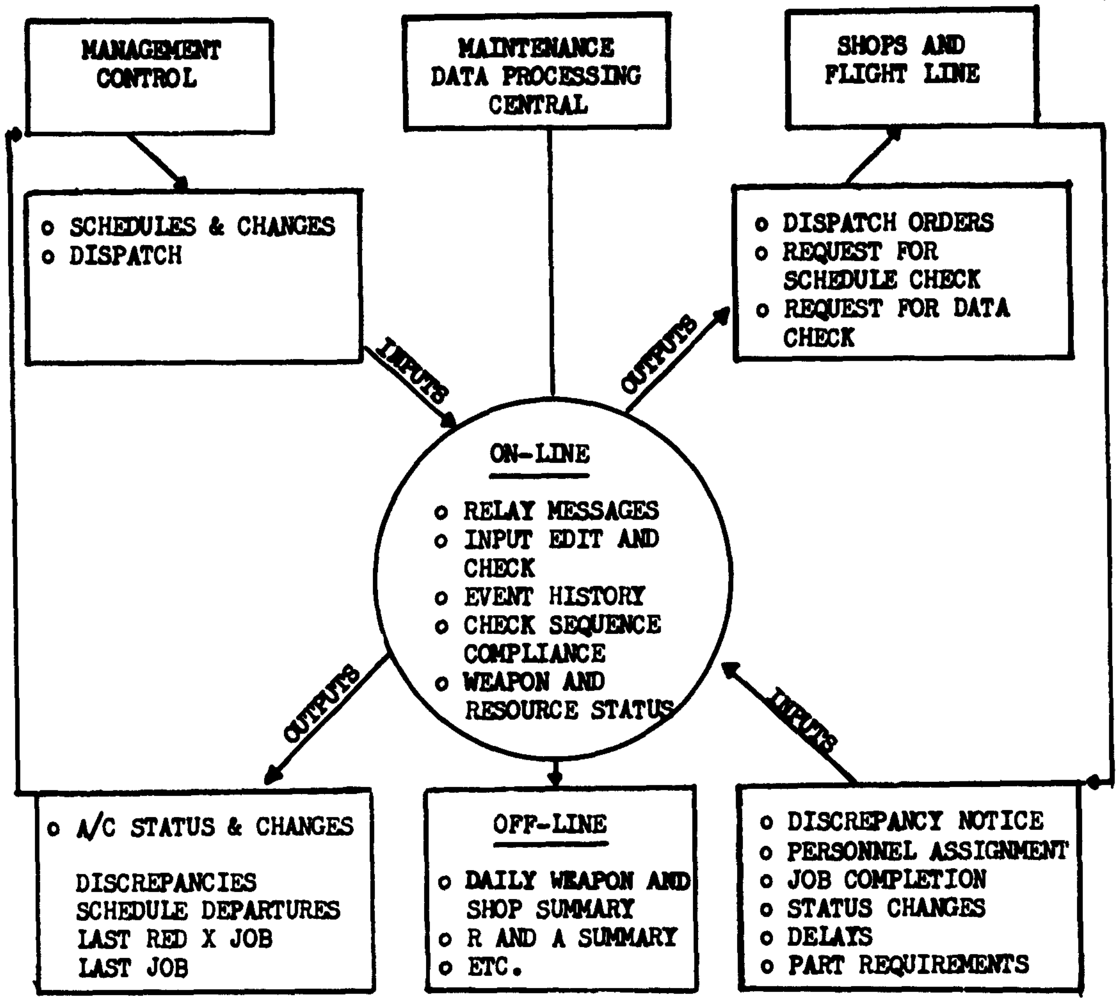

Fig. 1 -- An Advanced Data Processing Framework

operation period, some confusion and problems are sure to exist. Once the system is shaken down, however, the data flows should be accurate and reliable. At this point the second phase can begin.

Phase two will incorporate some analysis functions into the processor itself. For example, the computer on receipt of operational requirements and discrepancy information would prepare proposed alternative schedules, would advise shops to dispatch certain skills and equipment to a particular aircraft at a particular time, would be advised directly of completed repairs, would propose schedule revisions and would routinely prepare regular reports as well as special reports as a result of interrogations by managers. This kind of system may be an especially attractive one to study in the context of the multi-weapon-multi-command setting.

QUALITY CONTROL CHECKS

Under current procedures, computers are being used at Depot level to perform only modest types of 66-1 data checks. We envision using computers on-base to perform extensive consistency-type checks and provide feedback to the person generating the report when errors have been committed.

FORMS AND CODES

We might do well to touch upon the design of codes and forms within the current data processing framework as well as an advanced hardware framework. It was not too long ago that form completion could be characterized by verbal information. With the shift to machine processing, there has been the tendency to have the man fill

out forms in ways that appeared to be convenient to the machine. We have underway a side study in the human factors of form design and form coding. The results of this study should help verify a trend away from straight random-type numerical codes to a judicious combination of alpha-numeric coding which can be handled more easily by the human recorder. This study should also add to our information concerning detail levels that the human recorder can handle through coding structures, as well as methods appropriate to training personnel in code use.

VII. THE MAN-MACHINE SIMULATION SYSTEM

Since a major share of the LP-IV is to be invested in that research technique which we refer to as man-machine simulation (or sometimes as "game-simulation"), it might be appropriate for us to spend several minutes describing this technique.

As you see from Fig. 2, man-machine simulation is made up of three major components -- AF participants, the Lab staff, and the computer. The AF participants will use the policies which we are interested in observing, evaluating and demonstrating. As currently envisioned, we will have on our LP-IV floor the DCM, Job Control, Production and Materiel Control, Maintenance Plans and Schedules, Reports and Analysis, and Work Center supervisors. I should like to emphasize that these Laboratory activities are to be manned by experienced AF managers. They will perform in the Laboratory those functions that they perform in the real world such as scheduling, dispatching, controlling reparables, completing and maintaining the AF maintenance data system, and analyzing performance of the total maintenance system as well as individual elements of the system. If we have done our homework well, the managers on our Laboratory floor will consider that the problems they face are similar to ones they experience in the real world, and that the resources they are able to manipulate in the Laboratory likewise resemble the resources capabilities available to them in real world. They will then be able to help us determine how well the proposed changes to the current system might work in the real world, and perhaps, they will help us to make even other changes for the better.

AIR FORCE PARTICIPANTS

DCM PLANS AND SCHEDULES JOB CONTROL PRODUCTION CONTROL REPORTS AND ANALYSIS W. C. SUPERVISORS	SCHEDULE DISPATCH CONTROL REPARABLES MAINTAIN AF DATA SYSTEM ANALYZE PERFORMANCE

LABORATORY STAFF

COMPUTER I/O

SIMULATE OTHER ECHELONS

EXPERIMENTAL AND QUALITY CONTROL

CLOCK MANAGEMENT

COMPUTER

GENERATE DISCREPANCIES

COMPUTE JOB TIMES

KEEP TRACK OF TIME, MAINTENANCE MEN, JOBS, PARTS, WEAPONS AND EQUIPMENT.

Fig. 2 -- The Man-Machine Simulation System

As you can see from Fig. 2, problems confronting the manager and the resources available to him to solve them are lodged and generated within the computer. This computer, an IBM 1401, is also on the Laboratory floor and, as you can see from Fig. 2, provides a means for generating weapon malfunctions, and a means for making available the men, equipment, weapons, parts, etc. necessary for the manager to carry on his managerial functions.

Figure 2 describes briefly the functions of the Lab staff during the course of a run. Our maintenance managers on the Laboratory floor will need to talk to Operations, higher echelons, and other organizational elements in the course of their typical activities. Though we are not particularly interested in studying the <u>internal</u> operations of these "embedding" organizations, they must be represented if we are to create realistic settings in which the maintenance managers are to operate. "Embedding" functions are represented by our Lab staff as well as by AF personnel on what we call "Top Deck" which plays the role of intermediary between the manager and the manager's world located in the computer. Computer access for input and output is thereby arranged through "Top Deck." "Top Deck" also exercises important functions related to experimental and quality control.

The three components briefly described might operate in the following way. "Top Deck" may announce an operational program, the maintenance objectives and maintenance policies. These goals are fed into the maintenance planning functions of the organization represented by our floor participants. These determine the schedules

to be implemented. Our managers would then take various actions to meet the schedule. However, as they "moved" their weapons in the computer from one status to another, they would find that malfunctions arise of approximately the same kind and frequency that occur with their real-world counterpart weapons. If, for example, a hydraulics malfunction occurs and changes the status of the weapon, that information would be fed Job Control calling for hydraulics specialist dispatch. Job Control would arrange for the dispatch with the Work Center Supervisor who, in turn, informs the computer that such and such a task had to be done on such and such an airplane. This would change the status of a hydraulic specialist inside the computer from "available for assignment" to "assigned" to a particular job. He would be held in that status for an appropriate period of time, until a report would come back to Job Control Center that the maintenance action was done. This specialist would then revert to "available for assignment" status. This sequence would also modify the status of the aircraft; the job would have been accomplished, and the aircraft would revert to "alert."

In addition to the information system available to the participants, for example, the existing 66-1 or a modified version, we have devised a lab data system which permits us to obtain data not normally available to managers. This provides us with detailed data with which we can analytically assess the adequacy of some policy or sets of policies under study.

As you can imagine, activating a realistic AF organization on the floor, in the computer, and on "Top Deck" takes a lot more detail

than most other techniques used in the assessment of management policies, with the possible exception of real-world field tests. There is obviously a big step between a good idea checked out through some analytic technique, and implementing this idea in the context of a complicated organizational framework. The man-machine laboratory provides us with a means for getting close to the practical and messy problems of real-world implementation without losing important experimental control permitted by the laboratory. In LP-IV, we think we will have developed the basic framework for testing the policies that are worthy of test. We also think the Air Force will find the Laboratory a useful vehicle for checking out and developing the procedural details of policies. Such a system, fairly quick and relatively inexpensive, should assure smoother and more successful field tests.

VIII. APPROACH

As a first step in the achievement of the objectives framed for LP-IV, we have been spending a considerable amount of time on a number of air bases within SAC, ADC, and MATS.

To supplement the information available through background research accomplished by RAND and others, we reviewed with base maintenance personnel the kinds of decisions they make, the kinds of information they need to make these decisions, the kinds of information available to them, what they do with the information, where they get it, and the like.

We also spent considerable time identifying significant problem areas with base personnel.

In order to build the man-machine models which realistically represented base maintenance organizations, it was necessary to have in detail, not only operating procedures, but malfunction rates of parts, the kinds of people required to do different kinds of maintenance work, the kinds of equipment they need, the times required for repair, and so on. In contrast to previous LP's, we made an early decision in LP-IV to use to the maximum extent possible maintenance data accumulated under the current AFM 66-1 in order to stock the computer and floor models. The wisdom of this decision is still being debated by some members of our staff. To use the 66-1 data in our Laboratory, it was necessary to examine it in detail and "work it over" in ways not typically done by the field. The preparation of the data for Laboratory use took us many more man-hours than anticipated. We have several important consolations, however:

One: Our knowledge of 66-1 data and its characteristics has grown by leaps and bounds. What we learned is currently being documented so that those of you who are interested in such details can share the outcomes of the weary hours spent with the data.

Two: Since we are using real-world data, when we run the Laboratory we will be in a position to estimate whether our Laboratory models operate similarly to the models that exist on base. We will be able to compare Laboratory alert rates, turnaround times, malfunction rates and the like with the rates as they occur in the Air Force. Furthermore, we will be able to assess whether measures in the world covary as they do in the Laboratory. For example, in the real world we have computed the relationship that exists between sortie rate and overtime rates. We hope to approximate such rates in the Laboratory.

Thus, you can see that we are initially building a benchmark case which approximates current AF practice. This benchmark provides the yardstick from which we subsequently will measure the effects of policy innovations. For the benchmark case or "B" run as we call it, we have data from B-52/KC-135 organizations.

While some of us have been concentrating on the problems of building the Laboratory models and gathering data for stocking these models, others of us have been reviewing the various management system ideas that have developed over the years through experience and research. A similar process has been going on with regard to the

various maintenance policy ideas that are available to serve as policy directions for LP-IV.

Our strategy is to plan for what we call a "B+1" set of runs and a "B+5" set of runs. The former would involve "modest" policy innovations -- ones that could be implemented in the Air Force in less than one year. The latter would involve policy innovations that would take on the order of several years to implement within the Air Force. One of our several problems in this area is to select from all of the alternative ideas available, and package them for our "B+1" and "B+5" runs.

One important technique that we are using to select out the promising alternatives for the "B+1" and "B+5" is an all-computer model.

But despite the several techniques available to us in choosing promising policy alternatives, we consider it important that representatives from Hq. USAF and from several major air command headquarters participate in the final policy determination deliberations.

IX. CURRENT STATUS

For the past several weeks, we have been in "mockup" mode. This permits us to wring-out our models and procedures in manual form. That is, we are in the throes of activating our base maintenance organization without benefit of the computer on the floor. While we are wringing-out floor procedures, information processing procedures and the like, our programmers are busily programming the 1401. Parenthetically, I should mention that our use of a mockup in the Laboratory has an important real world application. When installing a new information system, the mockup approach is a useful means for debugging it. We will be documenting the use of mockups for such purposes in the near future. In any event, our expectation is that we will be ready for computer supported runs or "record runs" of our B-52/KC-135 benchmark case in January, 1963. Prior to the mockup, the 15th Air Force provided significant project support by permitting our people to visit several of their bases, gather data of all types and observe in depth maintenance management activities. During the mockup, the 15th Air Force has provided three of their experienced managers to participate in our 60-day effort to activate our simulated Air Base. Obviously, we would not have been able to make the progress we have without the support from the 15th Air Force. We are grateful for this fine support and their continuing assistance assures us that the benchmark record run will be a rewarding one.

X. FUTURE PLANS

Immediately following the benchmark run simulating a SAC maintenance management organization, we intend to embark on a series of B+1 innovations. However, before we do this, we propose that representatives of Hq. USAF, SAC, ADC, TAC, AFLC, or other commands meet with us in Santa Monica for a day or two in January. Such a meeting would review in depth the policy innovations to be run during calendar 1963. In addition to discussions regarding policy innovations to be subjected to the man-machine simulation test, this meeting should also cover such items as validating our SAC benchmark run in the context of another command and across commands, maintenance management training requirements, and selected radical changes in base operations and logistics policies and concepts that are being planned or explored by the operational commands. The inclusion of the <u>anticipated</u> operational concepts in LP-IV should further assure us that the outcomes of LP-IV are indeed relevant to the future as well as the present.

XI. CONCLUSION

We anticipate that the intensive efforts of LP-IV in behalf of base maintenance management and information systems will contribute significantly to improving these activities on base. To be sure that payoff from LP-IV does not need to await final outcomes of the project, we are phasing our work so that findings for innovations that do not require new equipment developments will become available in early stages of the project. Furthermore, in preparation for our man-machine runs, we are doing a significant amount of analytical work. The findings will become available as rapidly as they can be documented. We also believe that our interactions with base, Air Division, and numbered Air Force personnel in the last several months has been of mutual benefit. LP-IV is dedicated not only to making new findings, but communicating old, as well as new findings to the Air Force; we trust, therefore, that we will be able to work out a sensible approach to the problem of assuring good information feedback. We suspect that one approach to the feedback issue is the presentation of findings to appropriate audiences within the context of brief demonstration runs of our man-machine simulation. We believe that the amount of detail and realism built into our man-machine simulation will better permit our Air Force audience to assess the relevance of our findings. Hopefully too, presentation of major findings in the context of a brief demonstration run will sensitize our audiences to the opportunities that exist for the experimental exploration of the future -- today.

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